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(पहला पुनरीक्षण)

Indian Standard

GUIDELINES FOR DE-ICING SYSTEM FOR HYDRAULIC INSTALLATIONS

(First Revision)

ICS **93.160**

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NEW DELHI 110002

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Hydraulic Gates and Valves Sectional Committee, WRD 12

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Gates and Valves Sectional Committee had been approved by the Water Resources Division Council.

It is desirable to provide ice-prevention or de-icing systems for hydraulic structures located in areas where low winter temperatures cause heavy ice formation. Such system when operated prior to freezing of the surrounding water. will prevent the formation of surface ice in critical areas and/or remove ice already formed, if operated after freezing. Ice prevention system may be used for various purposes, such as protecting the civil structures and gates against ice pressure, keeping intake gates,intake stop logs, spillway gates, draft tube gates. etc. free of the ice formation in between stationary embedments and the moveable gate components which either remain in contact or have very small clearance or preventing building up of ice against these structures and eliminating obstructionary influence of ice on the operation of hydraulic control gates.

In cold climate, ice formation on crest and gates in open air should be prevented to ensure that they remain operational as and when needed. If not done, ice will form in great quantities below leaky gates and the entire upstream face of exposed steel gates will be coated with the ice several centimetres thick. The ice which forms on the face of the gates may be too heavy, for the hoists to lift. The ice **will also adhere to the piers** and sill. The ice must be kept clear of the upstream face of the gate, not only to permit operation but also to prevent thrust from the ice sheet against the gates. This thrust has been known to damage the gates to a considerable extent.

Dependable operation of crest gates requires that lifting equipment can be made to function without fail.To achieve this the water in contact with gate on the upstream side, the guides, support roller tracks or sealing strips should not be allowed to freeze.

The operation of mechanical/manual removal of large quantities of ice already formed in the gates is both slow and expensive. Also, unsuccessful operation of frozen gates when required to pass sudden floods may endanger the safety of structure. It will be therefore economical to make provisions in the gates to prevent ice formation.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value. observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised)‘.* The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard
GUIDELINES FOR DE-ICING SYSTEM FOR HYDRAULIC INSTALLATIONS
(First Revision)

1 SCOPE

‘This standard provides general guidance for the de-icing systems that can be employed to prevent ice formation in the hydromechanical installations of hydraulic structures located in areas where low winter temperatures cause heavy ice formation. These include dams, intake structures, trash racks,spillway gates, etc.

2 REFERENCE

The following Indian Standard contain provision which through reference in this text constitute provisions of this standard. At the time ofpublication the edition indicated was valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below :

IS No.	*Title*
6206 : 1985	Guide for selection, installation and maintenance of air compressors upto10 bars (*first revision*)

3 ICE FORMATION

3.1 In reservoirs under very severe cold conditions three distinct forms of ice, namely, sheet ice, anchor ice and frazil ice are likely to be formed.

3.2 Sheet Ice

This is the ice that gets formed in still water under normal conditions and exists as a surface layer.

3.3 Anchor Ice

Anchor ice consists of small ice needles which get formed at the bottom of fairly quiet, shallow bodies of open water or water covered by a thin transparent ice sheet. It appears usually on cold, clear nights and becomes loosened and floats away during the early hours of the day.

3.4 Frazil Ice

Frazil ice consists of fine spicular ice crystals floating in the water and formed by slight super cooling below 0°C. This ice adheres to the surface ice and to the anchor ice. In engineering work frazil ice is particularly objectionable as it adheres to the racks and to the gates. If due to exposure to the air, the gates or racks are slightly supercooled, the frazil ice freezes into one solid mass.

4 SPECIAL ASPECTS

4.1 In very cold weatherwhere there is likelhood of formation of ice sheet over the reservoir, the additional force on account of ice thrust should also be considered on the hydraulic structures under closed condition of crest gates. The point of application being near to the water surface level increases the overturning moment substantially due to high lever arm. The crest gates 3s well as spillway structure if not designed for this. ice thrust, may get damaged. In addition, both veertical lift and radial gates on spillways may cause operational difficulties due to increased operation friction caused by the ice.

4.2 When gate in hydraulic structures should be constantly available in operating condition in cold climate, adoption of the type of gates/its sealing arrangements should be suitable to reduce leakage to the minimum and the design and features of gate should be such that various methods of de-icing and ice removal are incorporated as per requirements of their site specific.

Gate embedded parts should be maintained ice free to minimize frictional forces and to prevent damage to. and gate bearing areas and guide elements by rubbing against ice build up. Where heavy ice build-up is expected next to the gate skinplate, heating should be provided for the skinplate to maintain a fhin film of water in between the skinplate and the ice sheet to keep the gate operational. This is most likely on the projects with relatively small reservoirs.

The sealing, bearing and guiding faces are generally in contact with or having very small clearances from the gate components are the critical elements/locations for freezing with every type of gate. On vertical lift gates, these critical locations are the roller tracks, seal seats, guides which must be kept free of ice to ensure good operation. Tight seals are important because leakage becomes the starting point for freezing and may build up large masses of ice on the down stream side of the seals which may cause trouble even if the seals and roller tracks and the guides are kept unfrozen.

The gate should preferably have upstream skin plate and sealing. As far as possible the gate should be located behind the crest wall/baffle wall. The top seal should preferably be located below the expected ice sheet thickness from full reservoir level.

4.3 In power plant intakes, located in cold climates, it is often necessary to adopt special precautions to prevent ice from interfering with the operation of plant. Frazil ice can travel significant distances beneath an ice cover and be a potential hazard at trash racks protecting water intakes against the passage of debris, trash, etc. The tendency for the frazil needles to adhere to the metal of the racks and to gradually build up an ice coating, may initially result in increased head loss at the rack and may ultimately seriously impede the passage of water through the rack and necessitate turbine shutdown.

It would be preferable to design trash racks to remain submerged at all times. It should be removable type and if so required, upper section of racks can be removed during winter flows, when floating debris are not expected to react the trash rack location due to ice cover.

4.4 Ice pressures are influenced by the nature of reservoir shore. Steep rocky shores offer higher resistance to an expanding ice sheet and as a result generally higher pressures develop than at flat and sandy shores. Field investigations may be necessary to determine the ice pressures and advisability of protecting certain hydraulic structures against ice pressures by de-icing systems.

4.5 To keep the hydraulic gate operable where ice formation is expected, the following may be given due considrations:

a) Provide heating system for the gate embedded parts and, if necessary for the gate skinplate.

b) Design the gate and the hoist with capacity sufficient to overcome to a reasonable extent, the increased ice loading.

c) Make the sealing arrangement leak-proof as far as possible.

d) Select de-icing arrangement/systems to sent site conditions.

e) Provide adequate drainage to-prevent ice building up on the downstream face of the gate.

f) Do not open the gate at too small an opening.

5 DE-ICING SYSTEMS

5.1 The following de-icing systems can be provided for ice prevention:

a) Air bubbler system, and

b) Heating system.

5.1.1 The crest type gates can also be provided with flaps at top, to be operated by hydraulic hoists or by other mechanical means. The operation of flap allows water disturbance underneath the ice sheet thereby resulting in breaking the ice sheet. This system is suitable for de-icing of ice sheet of lower thickness (up to about 250 mm) and can be used independently or in conjunction with heating arrangement in the embedments/gates.

5.2 Air Bubbler System

5.2.1 This system comprises essentially of air compressors to supply compressed air at suitable pressures to a main header(s) which in turn feeds control headers and then the distribution piping carrying nozzles at strategic locations, opening into the reservoir.

5.2.2 In a reservoir that is frozen, the temperature of water increases with depth below the surface of ice, varying from 0°C adjacent to the ice to approximately 3.9°C the temperature at which water has its maximum density. In the compressed air bubbler system, air is forced through nozzles into the reservoir at a depth of not less than 3 m, adjacent to the structure to be protected. The compressed air breaks into small bubbles and mixes with surrounding comparatively warm water. The stirring and mixing action of the released air induces a strong upward current ofrelatively warm water which either melts the ice already formed or prevents its formation.

5.2.3 This system is less common than the heating system because it is relatively slow and less efficient. Bubbler system installation are generally provided at intake trash rack location or where the reservoirs are large and the gates not operated in winter. Moreover this system is less effective in gate grooves where seals and trash racks are likely to freeze. The bubbler system should be continuously run during winter. This could prove too expensive depending on duration of winter usage.

5.2.4 Discharging air vertically down from the orifice results in a superior flow pattern. A discharge of 0.05 cu m of free air per minute is sufficient to induce a strong upward current. Circulation is effective for an area varying from 5 to 6 m in diameter around the orifice. This influences the spacing of air nozzles to provide the required coverage for the bubbler system.

For the purpose of spacing nozzles, circulation can be assumed effective in an area of 4 m diameter around the orifice.

5.2.5 Care should be taken not to thaw the ice away from the projecting nose of the pier, which should take the ice thrust. Conditions can be improved in this respect-if the piers at the gates extend considerably upstream so that the ice tends to span horizontally from pier to pier, instead of exerting pressure on the gate.

5.2.6 ***Compressors***

5.2.6.1 Air cooled compressors of the reciprocating piston type or rotary type according to IS 6206 may be used to supply compressed air. Up to discharge pressure 0.14 N/mm^2 gauge single stage air cooled. rotary compressors, which ensure smooth vibration less and continuous air delivery are preferred. The compressor equipment should include an air filter. intake silencer, automatic unloader, checkvalve, pressure gauge and an oil separator. An air receiver should be used when the volume of air header is less than that required to hold the total discharge of compressor operating for one minute, with initial and final discharge pressures at atmospheric pressure and the normal operating pressure respectively. Air receiver should be equipped with a drain cock and a safety valve.

5.2.6.2 Compressors should be of the constant running type supplying its full capacity to the nozzles, automatically unloading the full capacity of the compressor whenever a predetermined pressure is reached and automatically bleeding air off the cylinders whenever the machine is stopped. Capacity of compressors should depend on the operating head at nozzles plus all pipe losses.

5.2.6.3 The delivery of the compressor should be calculated on the maximum number of nozzles in use at one time. Maximum delivery should be 0.05 cu m per nozzle multiplied by the maximum number of operating nozzles and divided by the volumetric efficiency of the compressor at maximum operating pressure.

5.2.6.4 Maximum gauge pressure should be 5 percent or IO percent more than the sum of maximum reservoir head on the air nozzles, the differntial pressure across the nozzle and the pressure loss in the piping system.

5.2.6.5 It is desirable to install compressors in pairs, with electrical controls for alternate operation of about 8 h each. Fig. 1 shows typical air compressor and piping assembly.

5.2.7 ***Layout of Piping***

5.2.7.1 Each structure to be equipped with de-icing system should be carefully considered to ascertain the location of features requiring protection against ice formation. In dams where fluctuation of reservoir levels is anticipated during the winter months, two or more sets of distribution pipes may be installed at different levels to serve for the fluctuating water surface.

5.2.8 ***Placement of Nozzles***

5.2.8.1 Compressed air nozzles should be placed at elevations that will permit operation at a minimum

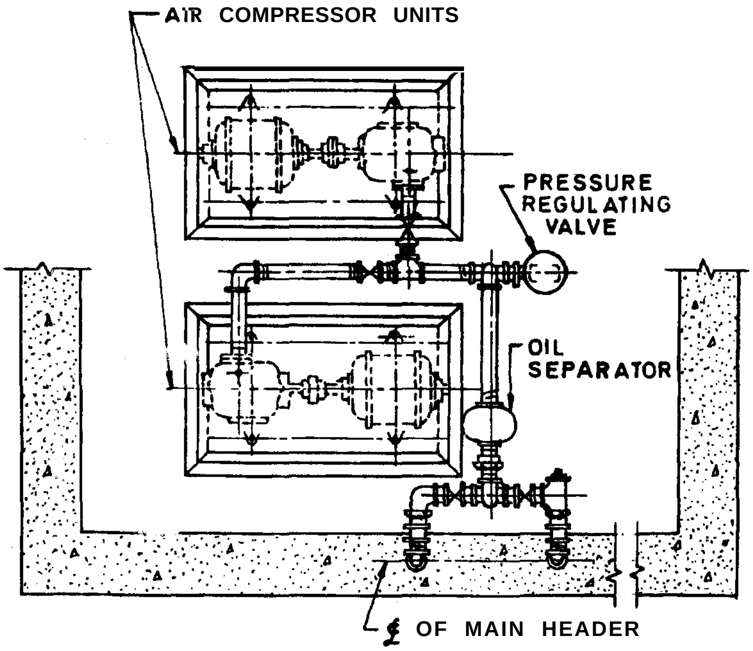


FIG. 1 AIR BUBBLER SYSTEM AIR-COMPRESSOR INSTALLATION

submergence of 3 m and a maximum that will permit the vertical flowing mixture of air bubbles and water to protect the structure above. The space between nozzles should not exceed 3 m which provides approximately 4 m diameter ice free area around nozzles. Each set of operating nozzles should be at the same elevation to ensure approximately equal discharges from each nozzle. The compressed air nozzles shall be provided with non-return valves to prevent back flow of water.

5.2.8.2 Fig. 2 shows typical arrangement of air nozzles for a trash rack structure.

5.2.8.3 For spillway gates the air nozzles should be located not less than 2 m upstream from the face of gates. A typical arrangement of air nozzles for a vertical lift gate is shown in Fig. 3. Nozzles of short tube type with a diameter of 3 mm and a length of 10 mm have favourable flow pattern and better non freezing characteristics.

5.2.9 *Air Header*

The main air header delivering air from the compressor to the distribution piping is usually placed in an inspection gallery in the dam or embedded in concrete. If embedded, the supply piping should be at least 1.5 m from the concrete face to prevent freezing. Galvanized steel pipes with galvanized iron or steel fittings are generally used for header.

5.2.10 *Control Header and Distribution Piping*

Control headers and distribution piping are made of brass, copper or galvanized iron or anodized aluminium or special PVC suitable for low temperature. Long radius bends, to facilitate cleaning when necessary, should be provided. The control header includes an intake valve, a throttle valve to the distribution pipe or pipes, a control valve for each distribution pipe and a drain valve. Normally the valves controlling the operating lines should remain fully open to allow the full compressor capacity to pass through the operating nozzles. Fig. 4 shows a typical control header branching from an air header located in an inspection gallery, with a shut off valve and a control valve to control the air flow in embedded piping leading to the air nozzles. Expansion joints should be provided for pipes running across the contraction joints of concrete dam or other concrete structures. These expansion joints absorb differential movement between adjoining concrete blocks.

5.2.11 *Installation*

Hydrostatic pressure should be maintained in the embedded piping during concreting and pressure grouting. The piping should be inspected for leaks while under pressure. Precautions should be taken to prevent damage to the copper tubing. Solder joints connecting the copper tubing and fittings should be made in accordance with good established practice.

5.2.12 *Operation*

Since the bubbler system is normally designed to use the entire capacity of the compressor, the operating control valves should normally remainfully open. A

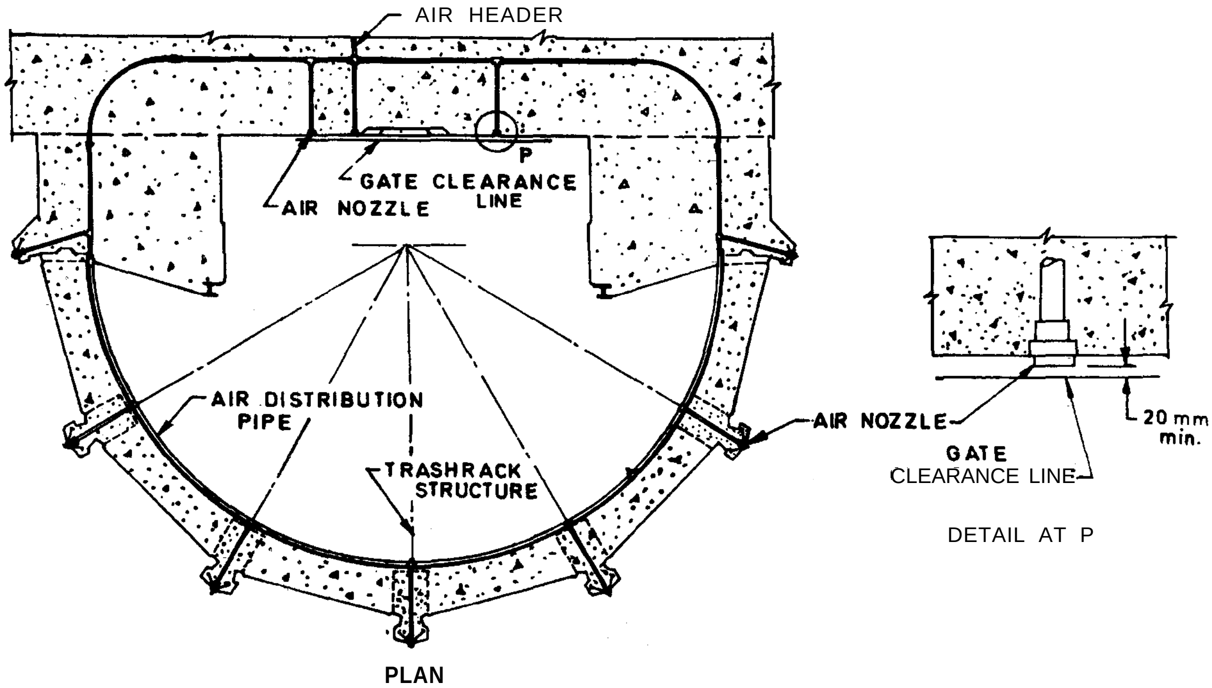
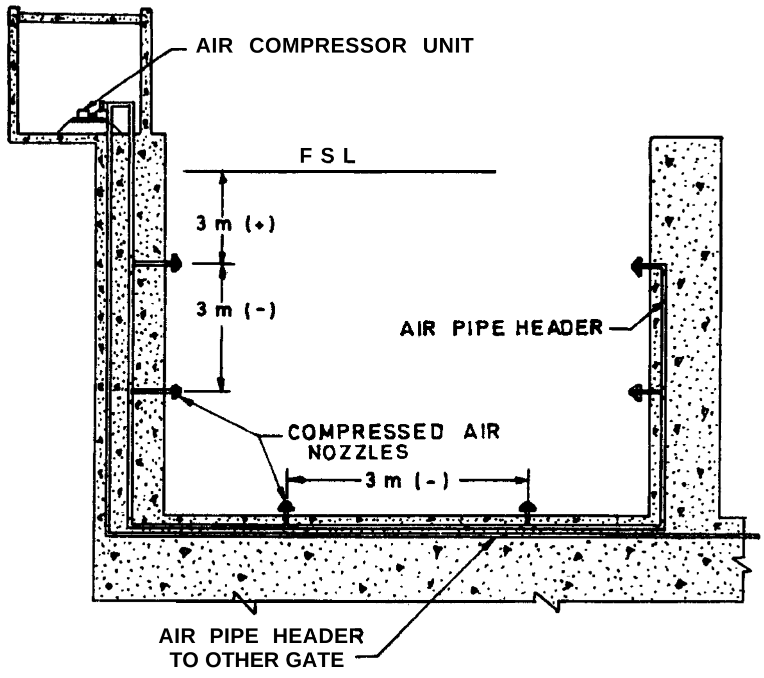


FIG. 2 DISTRIBUTION PIPING IN TRASH-RACK STRUCTURE



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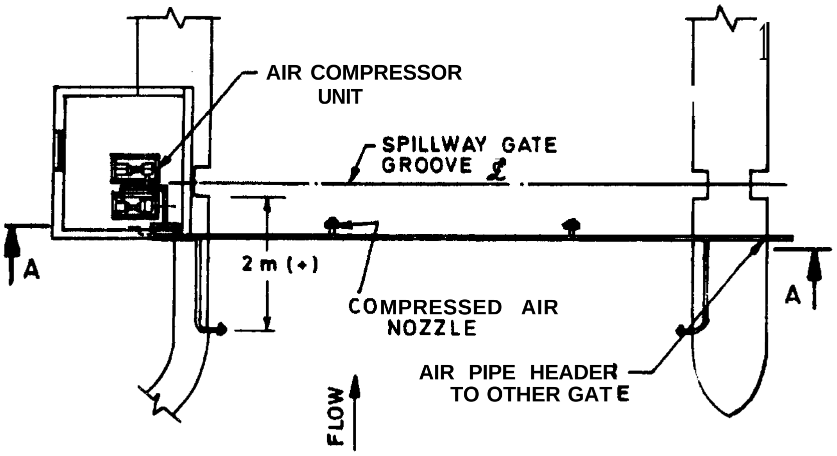


PLAN

FIG. 3 AIR BUBBLER SYSTEM SPILLWAY

curve showing compressor discharge pressures for varying reservoir levels should be prepared for operation on the basis of operating characteristics of the compressor. The proper use of control valves for both the operating cycle and the shut down cycle should be described in the operating instructions.

5.3 *Heating System*

5.3.1 Heating system is an effective means ofcombating ice on the gates because of fast action especially for de-icing of seals and tracks of vertical lift gates, radial gates and other operating points of gates.In this system heating is done by:

a) Electricity -on a cyclic basis controlled by timer and/or thermostat.

b) Steam -continuous heating is often desirable. and

c) Hot liquid or hot air-on acyclic basis controlled by timer and/or thermostat.

5.3.2 Heating by Electricity

5.3.2.1 Heating by electricity can be accomplished by either the straight resistance or the eddy current method. In recent developments electric resistance heating has been used almost exclusively. It is the simplest to apply and can be installed with the least trouble and with much less duct work than medium like stream and hot liquids.

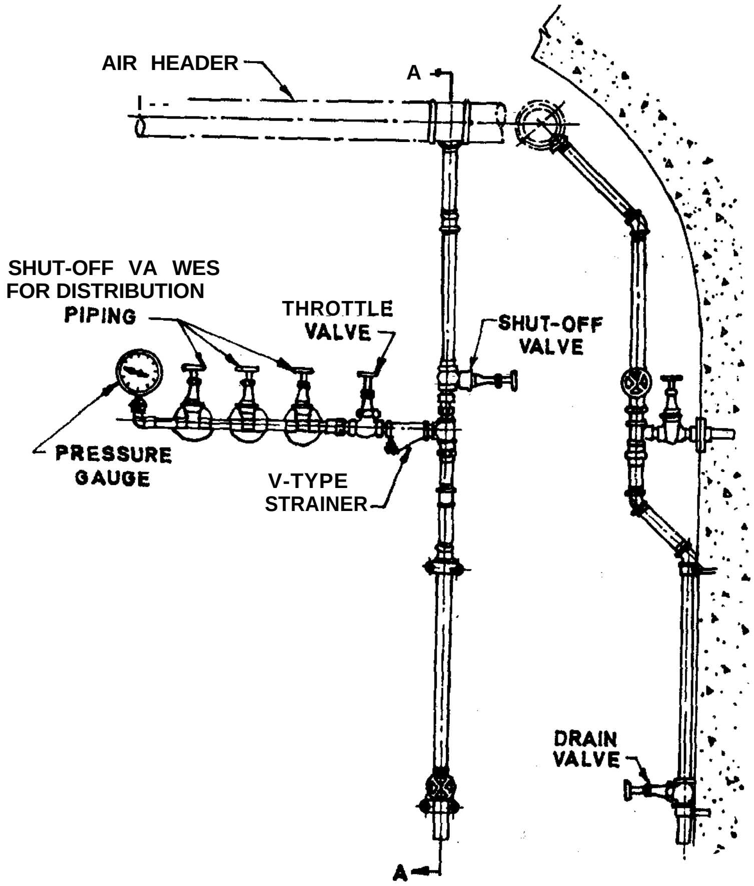


FIG. 4 AIR BUBBLER SYSTEM AIR-CONTROL HEADER

Electrical induction heating utilizes the heat generated by currents induced in a metal part by the process of induction.

5.3.2.2 In this method space heaters are provided in a housing in the concrete near the gate seals. The heating units should be of the tubular type consisting of helicaly formed coil of crome nickel resistance wire surrounded by refractory insulating material encased in a seamless tubes of corrosion resistant and non-oxidizing metal. On account of great masses of water and metal present the heating element should be of ample size.

5.33.3 To protect the concrete from very high temperatures resulting in cracking of concrete on cooling and to keep its temperature within the safe maximum temperature of 65°C, thermostats are used which disconnect the transformers automatically when the temperature is exceeded. The thermostats operate the breakers connected to high tension side of each transformer. Circuit breakers are designed for manual operation and it is possible to heat the plate on one side of pier without heating the other side.The possible temperature differential due to this condition may create special problems in the design of piers and it may become necessary to add extra reinforcing steel.

5.3.2.4 Suitable insulating material, like asbestos. should be provided in the block out behind the housing of the heating element to protect the concrete surface from cracking and deterioration.

5.3.3 *Heating by Steam*

5.3.3.1 In this method steam pipes are embedded in the concrete, housed in steam cells near the gate seals. The steam should necessarily be supplied continuously during cold climate, because if the steam coils are allowed to cool, condensation may freeze them solid when steam is first turned on.

5.3.3.2 The usual method is to supply steam through water boiler which could be either the coal or oil fired type or the electrode type. Where the gates are in remote locations or there is likelihood of interruption in power supply it would be desirable not to depend on electricity for the boilers but to have sufficient supply of coal or oil for use during the winter months. The boilers should have to be able to supply steam at adequate pressure so that the steam can travel in the coils to the bottom most point and return to the condensation tank.

5.3.3.3 To protect the concrete from very high temperatures, thermostats are used to operate solenoid valves on the supply line.

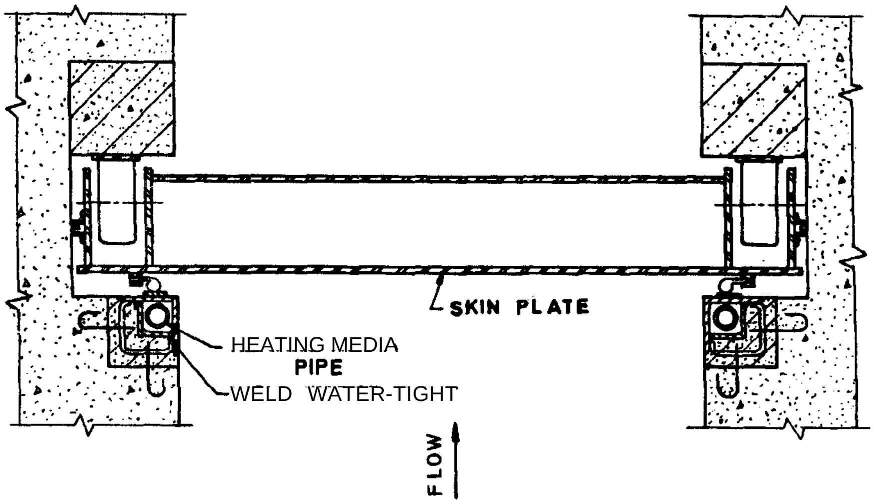
5.3.3.4 A typical arrangement of steam heating for a vertical lift spillway gate is shown in Fig. 5.

5.3.4 *Heating by Hot Liquid or Hot Air*

5.3.4.1 In this method a liquid having a low freezing point is heated by electricity and circulated through pipes embedded in concrete adjacent to the areas to be heated. By controlling the speed of circulation,temperature of the liquid should normally be maintained between **40°C** and **65°C**.

6 PERIODIC OPERATION OF GATES

In some hydraulic installations, if it has not been possible to make provision for any of the de-icing systems mentioned earlier, it may be possible to break up an ice formation by periodic operation of gates/regular cleaning of trash-racks during periods of severe frost. This may ensure satisfactory operation of gateswhen required.



PLAN

FIG. 5 HEATING SYSTEM BY HOT LIQUID/AIR OR STEAM

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